

# **SI-EGR NG Engine w/TWC**

## **Project Update NGNGV Steering Committee**

**July 23, 2003**

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**Cummins**

# Review Topics

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- **Program Overview**
- **Targets**
- **Technology/benefits**
- **Schedule**
- **Status**
- **Next steps**

# Program Overview

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- Demonstrate a high efficiency low emissions SI Natural Gas engine with cooled EGR
- Apply Cummins EGR technology to SI Natural Gas
- Diluting with EGR instead of air allows stoichiometric operation and use of a three way catalyst
- Demonstrate diesel like peak thermal efficiency, bmep and 2007 emission targets

# **Program Overview (cont.)**

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- **2 year program**
- **Cummins main subcontractor**
- **Westport subcontractor to Cummins for catalyst develop.**
- **Contract signed by SCAQMD July 7th 2003**

# Technology / Benefits

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- **Stoichiometric operation allows use of a three-way catalyst**
- **EGR HD systems availability made possible this approach**
- **Cooled EGR**
  - **Dilutes charge and lowers combustion temperatures for lower NOx output**
  - **Suppresses knock tendency allowing higher bmep**
  - **Higher bmep results in improved thermal efficiency**
  - **Cooled EGR improves ignition system durability**
- **Technology can be applied on various platforms and applications**

# Project Targets

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	SI - EGR TARGET	Current C8.3 Gas Plus
Rated Power (BHP)	310	280
Torque Peak lbs-ft (lbs-ft)	950	850
BMEP @ Rated Power (psi)	202	183
BMEP @ Torque Peak (psi)	283	254
Torque Peak Ther. Effic. (%)	40	36
FTP Emissions g/bhp-hr	w/TWC	w/OC
NOx, NMHC, Formaldh.	0.2, 0.14, 0.01	1.5, 0.2, 0.019
PM	0.01	0.01

# Schedule

SI - EGR Natural Gas Project - SCAQMD											
			Year 1				Year 2				
Task Name			Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	
1. Engine Perf. Model Build & Simulation											
2. Modeling of Optimized Hardware											
3. Design & Integration of New Compon.											
4. Controls Model Build & Simulation											
5. Design of Optimized Hardware											
6. Controls Optimization											
7. Engine & Component Sourcing											
8. Test Cell Readiness, Engine Bld & Start											
9. Baseline Perf. & Steady S. Optimization											
10. Transient Optimization											
11. Steady St. Perf. & Emiss. w/Optim. HW											
12. Trans. Perf. & Emiss. w/Optim. HW											
13. Catalyst Selection & Testing											
14. Robustness Verification											
15. Endurance Validation											

# Status

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- Literature review completed
- Modeling, Design and controls activities on-going
- Procured C Gas Plus engine
- Analysis confirms efficiency improvement

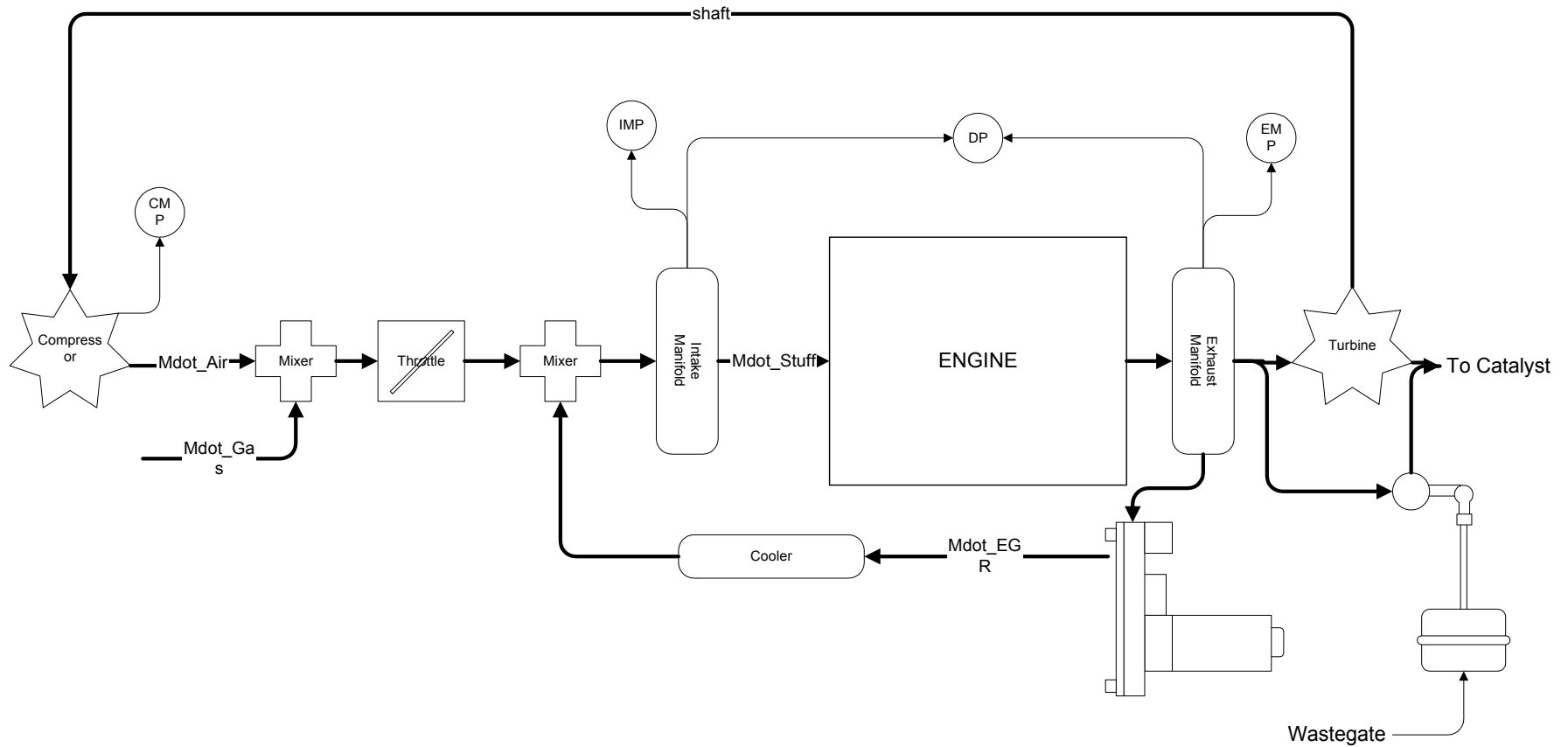


# Project Challenges

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- Ability to control the A/F ratio during transients
- Cylinder to cylinder variation
- Driving sufficient EGR near the torque curve
- Maintaining stable air handling operation
- Increase in max bulk in-cylinder temperature
- Increased coolant flow needed

# System set-up



# Peak bulk temp analysis

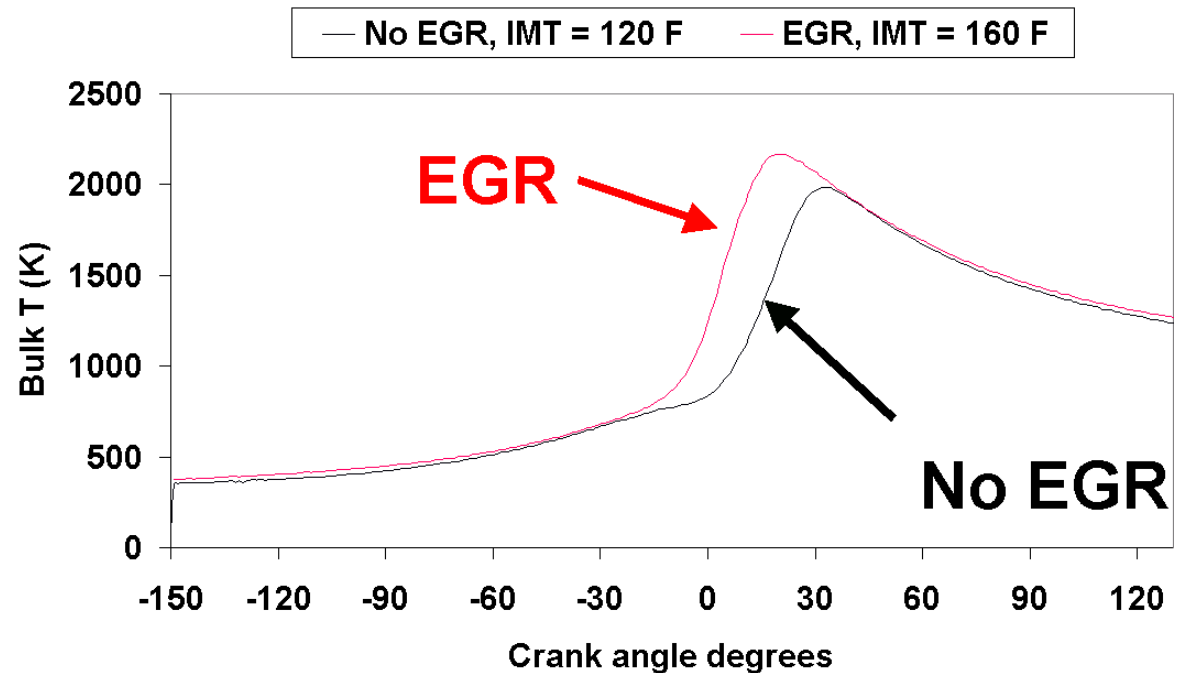
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Peak bulk T is about 10 % higher

**Due to:**

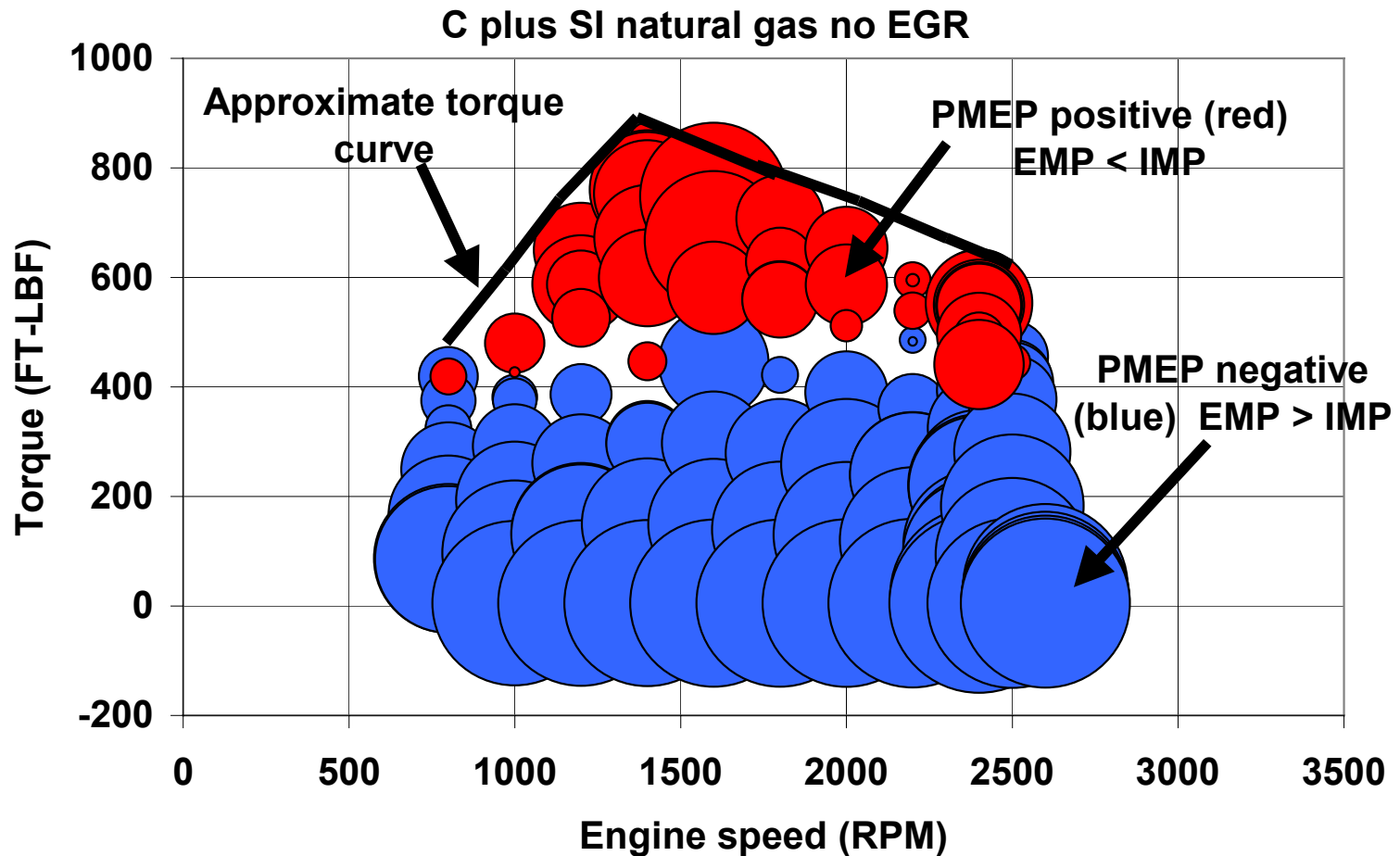
- higher CR
- higher IMT
- more advanced heat release

How do Bulk temperatures compare between EGR & non-EGR  
SI nat gas engines?



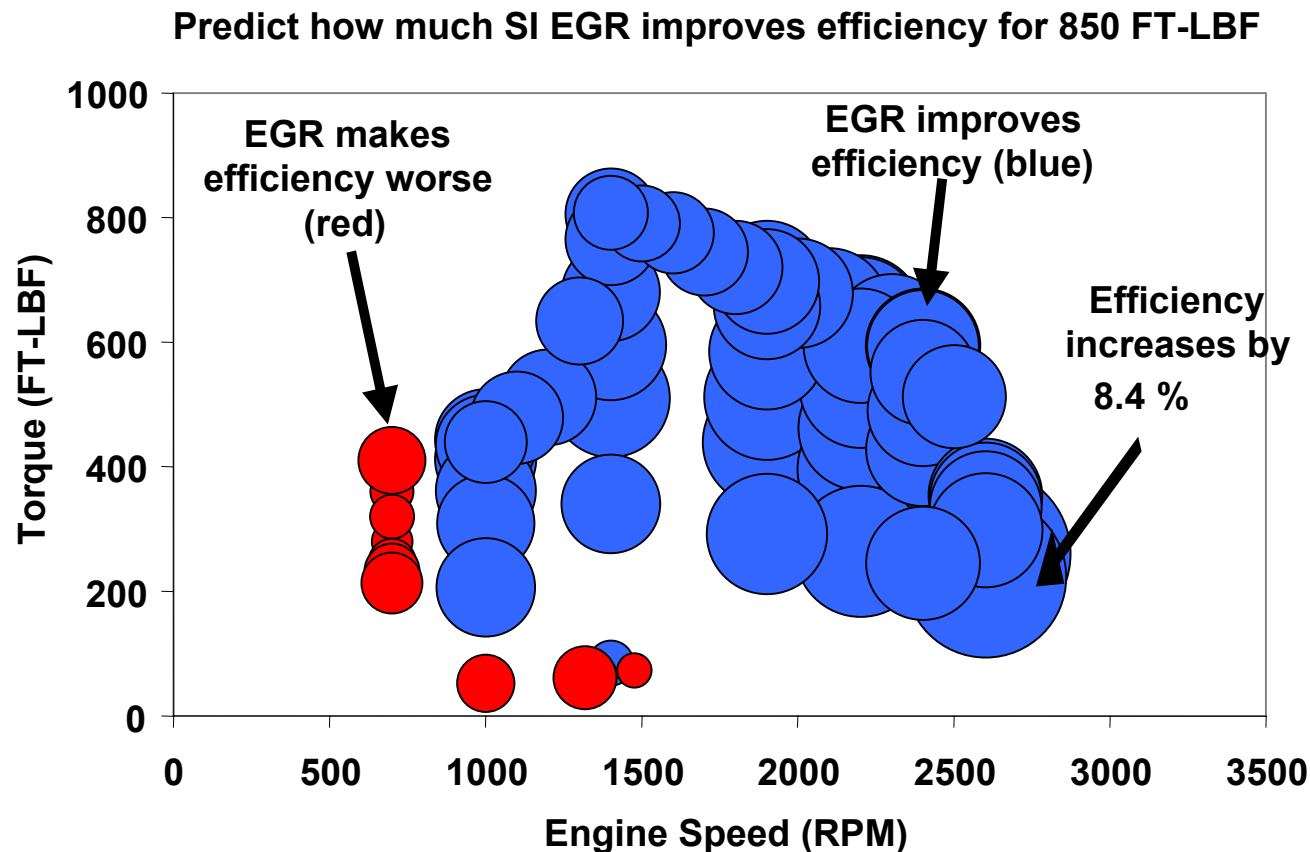
# EMP vs IMP Mapping

EMP > IMP on C Plus engine most of the time



# Efficiency Analysis

Brake Thermal Efficiency w/EGR (17.5 bar @ Torque Peak)



# Next Steps

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- **Continue GT-Power model development**
- **Simulate High Pressure and Low Pressure EGR loops**
- **Continue Controls System models**
- **Piston bowl analysis**
- **Continue Design Activities= HD EGR system adapted to C8.3 Gas Plus engine**